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EVALUATION OF SOIL DEGRADATION AS A FACTOR AFFECTING FOREST PRODUCTIVITY IN BRITISH COLUMBIA - A PROBLEM ANALYSIS PHASE II & III - RESEARCH NEEDS & POLICY EVALUATION

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ECONOMIC & REGIONAL DEVELOPMENT AGREEMENT

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ABSTRACT

PREAMBLE

Phase I of this study (Utzig and Walmsley 1988) outlined the nature and extent of soil degradation effects on forest productivity in British Columbia. This report constitutes Phases II and III of the overall study.

OBJECTIVES

The objectives of this report are to outline appropriate research needs and strategies, to evaluate current legislation, policies and regulations and to examine the adequacy of staffing levels and training programs to deal with the identified concerns.

METHODOLOGY

Data and information were gathered principally through interviews and discussions with individuals in the forest industry, and federal and provincial government personnel in their respective forest ministries and private forestry and soil consultants. Pertinent literature and summary data available from the Ministry of Forests and Lands were reviewed and incorporated in the study. Results of the Phase I report were fully used throughout this report.

CONCLUSIONS AND RECOMMENDATIONS

A review of current and proposed research about soil degradation effects on forest productivity coupled with an identification of research required resulted in the development of six initiatives of provincial priority:

1. *The development, testing, implementation and enforcement of policies and procedures for protection of soil productivity.*

2. *The development of techniques for assessing soil productivity and for prediction of where a reduction of soil productivity can be expected because of management practices and specific soil conditions.*

3. *The development of a comprehensive research program, including the elaboration of site specific research needs to evaluate the effects of management practices on individual soil types.*

4. *The development of specific soil monitoring and assessment plans and procedures to investigate and evaluate changes in soil productivity.*

5. *The provision of appropriate practices to rehabilitate soils whose productivity has been reduced.*

6. *The assessment of the potential for improving productivity by the use of soil amendments and nitrogen-fixing species.*

Current legislation and policy regarding the protection of forest soil productivity is considered to be inadequate. It is recommended that immediate attention be given to the development of pertinent legislation and the implementation of effective soil conservation strategies to alleviate the ongoing and historical loss of forest productivity resulting from soil degradation.

Government and private sector staffing levels and budgets are regarded as inadequate to effectively deal with the current situation. It is recommended that a training program be designed and implemented immediately to raise the awareness of industry and ministry personnel with regard to the consequences of soil degradation. The training program should also be aimed at improving planning of harvesting operations and silviculture treatments to reduce the occurrence of soil degradation. It is also recommended that government and industry increase the levels of trained staff for research, operational and monitoring programs, and provide sufficient budgets on a program basis for undertaking the required tasks.

The analysis of personnel requirements and costs to implement a soil degradation program are estimated at $715,000 per year for a `minimum' program and $1.56 million dollars per year for a `recommended' program. Additional costs for `one-time only' requirements are estimated at $1 million dollars. The Phase I Report (Utzig and Walmsley 1988) estimated the annual increase in productivity losses province-wide to be $10 million dollars. A reduction of the annual accumulation of productivity loss by approximately 18% will make the minimum program cost-justifiable while a reduction of 26% will make the recommended program cost-justifiable.

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1. STUDY OBJECTIVES AND RATIONALE

The objectives of this study are to identify the nature and extent of soil degradation on forest land in B.C., to evaluate its effects on regeneration/ plantation performance and to recommend procedures needed to improve soil management and forest regeneration procedures. The overall study has been subdivided into three specific phases designed to accomplish the requirements of these objectives. Phase I of the study was completed in March of 1987 and critically reviewed by the Canadian Forestry Service (CFS) and their designates. It dealt with the issues specifically related to the nature and extent of soil degradation in the province. The Phase I report contains a significant amount of the background material used in the preparation of this report. Consequently, this information will not be repeated here and the reader is urged to read the Phase I report in conjunction with this document.

Phases II and III of the study are the topic of this report. These phases deal respectively with research needs and strategies, and the adequacy of current regulations, staffing levels and education to deal with the identified issues.

Soil degradation is a major concern to forestry managers in B.C. because it can decrease the survival and growth of regenerating stands as well as reduce the success of restocking backlog sites. Impacts such as soil compaction and nutrient reduction due to harvesting and/or silvicultural treatments can result in long-term growth reduction even though the treatments may bring about short-term growth increases. A lack of understanding of the extent and magnitude of issues such as these, and the means of effectively dealing with existing and potential future soil degradation are constraints on management. As a consequence of these cause and effect relationships, forest managers may have to face reductions in long-term sustainable yield and limitations on the use of specific logging methods, silvicultural systems and silvicultural treatments. Research studies, the implementation of realistic site degradation policies and procedures, and improvements in education and training will provide the means of overcoming these constraints.

Information contained in this report was obtained by discussions with soil scientists and foresters in government and industry as well as appropriate research personnel in the Canadian Forestry Service and through the synthesis of appropriate literature.

2. INTRODUCTION

The results of the first phase of this overall study suggest that soil degradation created by forestry practices over the ten year period of 1976 to 1985/86 is presently causing an annual loss to the provincial economy of approximately 80 million dollars, and that this is increasing by 10 million dollars per year. By the year 2000, soil degradation could be creating a loss of over 200 million dollars annually.

These figures are significant given that B.C. contains approximately 18.5% of the productive forest land in Canada, and moreover that B.C. forests account for approximately 27% of Canada's total mean annual increment of wood fibre. Given the importance of the forest industry in the provincial economy and its significance to the national economy, the potential reduction of long-term sustainable yield resulting from soil degradation cannot be ignored.

Both the federal and provincial governments have recognized that productive forests are essential to the economy of the province. Some of the objectives of the Ministry of Forests Act (1979) are "to encourage the attainment of maximum productivity of the Forest and Range resources in the Province" and "to manage, protect and conserve the Forest and Range resources of the Crown, having regard to the immediate and long-term economic and social benefits they may confer on the Province..." (Province of British Columbia 1981).

Concerns held by the Federal Government are expressed by two initiatives supported by the Federal Cabinet. They are: the need to ensure sufficient wood supply in Canada through forest renewal; and to support mission-oriented research and development (Environment Canada 1982).

The findings and conclusions contained in this problem analysis are intended to provide focus and direction for attaining these government objectives and initiatives related to the issue of soil degradation. They are not solutions in themselves.

3. RESEARCH NEEDS AND STRATEGIES

3.1 INTRODUCTION

In order to place recommendations into a framework, it is first necessary to understand the nature and extent of current and on-going research directed toward soil degradation issues in B.C. While research and educational programs being used outside of B.C. will undoubtedly be of value, it is suggested that the most relevant are those being undertaken here.

Recommendations for research programs are subdivided into six basic categories. These being:

- o Harvesting Technology
- o Site Preparation
- o Site Rehabilitation
- o Prediction, Assessment and Monitoring
- o Planning
- o Economics

This categorization is useful for identifying specific issues, but is somewhat cumbersome since several potential research topics span more than one category. Research recommendations in this report are made with the understanding that work be conducted within the standard framework of the biogeoclimatic system, particularly in respect of the notion of a `treatment unit'. By conducting research in this manner, it will be possible to build a scientifically credible data base while at the same time providing directly applicable information for operational forestry programs. Information collected on one area can be easily extended to other ecologically similar areas.

The recommendations made in this report are not solely those of the authors. In large part, they are based on discussions with research and operational foresters and soil scientists in B.C. and the Pacific Northwest as well as a number of pertinent articles which have recently been written on the subject.

Pervading the entire range of recommendations which follow, is the understanding that B.C. represents an incredibly complex environment, not only from a soil, climate and ecological perspective, but also, and perhaps more importantly, from an administrative perspective. This complexity requires B.C. to develop programs which are distinct to its requirements. Approaches to the issues developed elsewhere will provide useful models but should not be viewed as being entirely applicable to the needs of B.C.

Research on a broad range of topics is required to assess the effect of soil degradation on forest regeneration and productivity. In general, knowledge of the effects relative

to specific B.C. conditions is limited. We support the recommendations of Still (1986), Runka and Bowden (1987) and others who have identified the need for coordinated research efforts which will provide knowledge on issues of interest not only to the Ministry of Forests and Lands but also to other ministries of government and the forest industry.

Any program dealing with soil degradation, be it research, institutional or educational, must balance the often mutually exclusive issues of short-term economics and environmental necessities in order to reconcile favourable cost-benefit relationships with the maintenance of sustained productivity over the long-term. The success of any program dealing with soil degradation issues will be largely determined by the effectiveness of dealing with these two perspectives.

3.2 CURRENT AND PROPOSED RESEARCH ON SOIL DEGRADATION IN B.C.

Information on soil degradation research efforts which are currently taking place in B.C. or which have recently been conducted was gathered during the literature review, data collection and interview phase of this study. In addition, each principal researcher in the Ministry of Forests and Lands (headquarters and regional), the Canadian Forestry Service (Pacific Forestry Centre), specific forest companies (e.g. MB, BCFP) and research institutes (e.g. FERIC) were contacted separately. The majority of these groups responded by providing a list of their research activities. This information is contained in Tables 1a to 1e. When utilizing the information contained in these tables, the reader should be aware that the list may not be comprehensive due to a lack of response from some areas. Also, emphasis has been placed on research activities conducted after 1982 because the majority of the work conducted in the province has occurred since that date.

The purpose of listing these research activities is three fold. First, to broadly determine the extent of research which is or has been conducted in the Province. Second, to examine the geographic location of the research and the research objectives. Third, to determine the applicability of the research findings. This framework will provide a means of rationalizing current research needs and avoid the potential for duplication of research effort.

Current and proposed research activities have been subdivided into five categories:

- Harvesting Technology (Table 1a)
- Site Preparation (Table 1b)
- Site Rehabilitation (Table 1c)
- Monitoring Systems (Table 1d)

o Technology Transfer (Table 1e)

Difficulty was experienced in assigning some research projects to one particular category because the objectives and resultant data of some research studies span several categories.

Notwithstanding this categorization problem, some preliminary conclusions can be drawn from Tables 1a, 1b, 1c, 1d and 1e:

1. The majority of research effort is being directed toward harvesting and site preparation technology and effects.

2. Other than by committees of government/industry, little research work is being conducted on monitoring systems and technology transfer (this does not mean to diminish the very important work being undertaken by these committees).

3. The majority of research in all categories is being conducted in the interior part of the province; the Prince George Region appears to be the centre of most work followed by the Nelson and Kamloops Regions.

4. The vast majority of research is being conducted by various branches and regions/districts of the Ministry of Forests and Lands and the Canadian Forestry Service. Only a few forest companies appear to be actively involved in research projects.

5. Some of what appears to be the most promising research is on the verge of being completed or is currently being conducted.

6. Little or no research effort is being directed at resource planning on economic issues such as TSA studies or cost-benefit analyses.

Undoubtedly, the significant increase in soil degradation related research over the past two or three years has resulted from both the recognition of economic implications and funding provided by the Ministry of Forests and Lands and the FRDA (Forest Resource Development Agreement) program. Poor economic conditions in previous years tended to reduce the effort of research and operational programs directed at soil degradation and rehabilitation.

Much research is still required, but ongoing research is producing a body of knowledge in the province which will provide a credible basis for action to resolve the identified problems. (See Phase I report for discussion of identified issues.) However, a critical obstacle to the satisfactory resolution of some soil degradation issues is the lack of effective dissemination of research results and the lack of a consensus as to what constitutes degradation. To date, little action has been taken toward resolution of

CURRENT AND PROPOSED RESEARCH ON SOIL DEGRADATION

Table 1a. HARVESTING TECHNOLOGY

TITLE	OBJECTIVES	PRINCIPAL RESEARCHER	LOCATION	TIMING
A Pilot study of Soil Disturbance on Selected Cutovers in the Prince George Forest Region	To determine extent of soil disturbance caused by harvesting activities	Angus Mclaod, MoFL	Prince George	Presented at 10th Soil Science Workshop
A Pilot Study of Soil Compaction on Skidtrails and Landings in the Prince George Forest Region	To determine extent of soil compaction associated with skidtrails and landings	Angus Mclaod, MoFL	Prince George	Presented at 10th Soil Science Workshop
Burton Rehabilitation Trials	To examine extent and degree of site disturbance on a severely damaged logging site	Co-operative work between Weldwood of Canada Ltd.&MoFL	Cariboo Forest Region	Ongoing
Martin Creek Project	Examination of soil disturbance/ productivity on downhill skidroads	Dick Smith, CFS	Vavenby, Clearwater Forest District	Soil & vegetation studies in 1984
Practical Method of Determining Road Cross-Section Geometry to Prevent Road Failures	To outline proper forest road geometry to prevent road failures, surface erosion and damage to adjacent aquatic environment	Steve Womoky, Research Branch MoFL Victoria	All Province	To be completed by 1991
Buckley Bay Mechanized Harvesting Seedling Survival and Growth Study	To compare seedling survival and growth on a hand-felled grapple-yarded area and feller-buncher grapple-yarded area to a feller-buncher skidder yarded area	Terry Mollerson, MB	Buckley Bay	3 year study; 87/ 88, 88/89; 90/91
Comparison of small Crawler Tractors, Rubber-Tired Skidding and Cable Yarding Harvesting Systems for Interior Steep Slopes	To compare the economic and environmental performance of three harvesting systems on steep slopes	Ray Krag, FERIC; in co-operation with Waldwood of Canada Ltd.	Quesnel Highlands Cariboo Forest Region	Proposed report by late 1987
Logging Coastal Sites in Wet Weather with Rubber-Tired-Equipped Skidders	To examine the economic and environmental feasibility of logging coastal sites in wet (winter) weather	Ray Krag, FERIC: in co-operation with MB(Cameron Div.)CFS, (Port Alberni District),MoEP (Fish&Wildlife Branch)and DFO	West Coast of Vancouver Island Forest Region	Proposed report by late 1988
Effects of Skidder Compaction on Tree Productivity	To examine the relationship between stand growth and soil compaction caused by skidder logging in coastal B.C.	Gordon Butt; project for MB	Central & Southeast Vancouver Island	Report submitted in March 1987
Compactive Effects of a Low Ground Pressure Skidder	To examine the degree and extent of soil compaction resulting from a low ground pressure skidder	MB	Coastal	Report prepared in 1984
Golden TSA Study	To evaluate the extent and nature of soil disturbance from forest harvesting for TSA analysis purposes	Steve Thompson & Gerry Still, MoFL	Nelson Forest Region	Ongoing; Publication in 1988
Timber Harvesting and Disturbance on Steep Slopes: Effects on Soil Properties and Forest Productivity	To document the environmental impacts of using ground-based timber harvesting equipment on steep slopes	Bob Mitchell, MoFL Kamloops; Bill Carr	Winnifred Creek and Railroad Creek	5 year study; to be completed in 1991
Winter Ground Skidding Impacts on Coastal Sites	Determine soil disturbance levels and changes in soil properties/productivity	John Senyk, CFS; FERIC; MB	Worthless Creek, Vancouver Island	Ongoing
Evaluation of Skidroad Layout and Harvesting Productivity	To investigate the effects of pre-designated skidroads on logging productivity and soil compaction	Ray Krag, FERIC in cooperation with Evans Products and MoFL	Golden TSA	Ongoing
Winter and Summer Harvesting Trials in Golden TSA	Determine extent and severity of soil disturbance by harvesting trial and effect on productivity	John Senyk,CFS;Evans Products; FERIC; MoFL cooperators	Golden TSA	Initiated 1988
Marl Creek Project	To determine disturbance/productivity relationships on contour skidroads	Dick Smith, CFS	Golden TSA	Planted 1985

CURRENT AND PROPOSED RESEARCH ON SOIL DEGRADATION

Table 1b. SITE PREPARATION

TITLE	OBJECTIVES	PRINCIPAL RESEARCHER	LOCATION	TIMING
Effects of Prescribed Burning on Productivity of some Coastal B.C. Sites	To examine the effects of different fire intensities on organic matter consumption, soil nutrients and tree growth; to monitor vegetation succession and soil erosion	Bill Beese, MB	South of Sproat Lake, Vancouver Island	Completion by 1991
Site Treatment Impacts on Site Quality	To document soil disturbance levels and changes in soil properties related to various site preparation methods	John Senyk, CFS	Golden TSA	Ongoing
The Effects of Mechanical and Chemical Site Preparation on the Soil Nutrients and Foliar Nutrient status of seedlings in the IDF, MS and ESSF Drier Subzones	To study the effects of forest floor removal, plus ripping and vegetation control with Roundup herbicide on soil and foliar nutrients	Bob Mitchell, MoFL, Kamloops, Andy Black and Tim Ballard, U.B.C.	Kamloops Forest Region	Proposed study to begin in 1988; 4yr duration
Prescribed Burning: Its Effects on Soil Properties, Tree Establishment and Growth in the Drier ESSF Subzones	To document the environmental impacts of broadcast burning on the establishment and early growth of interior spruce	Bob Mitchell, R. Brockley, and G.Hope,MoFL,Kamloops	Kamloops Forest Region,Okanagan Highlands	Proposed study to begin in 1988; 5yr. duration
Effects of various Site Preparation Techniques on Seedling Survival and Growth	To document the effectiveness of various site preparation techniques	Chris Thompson, MoFL Nelson	ICHaZ, Nelson Forest Region	Ongoing

TITLE	OBJECTIVES	PRINCIPAL RESEARCHER	LOCATION	TIMING
Longer Term Fire Impacts in Coastal B.C.	To examine the potential long-term impacts of fire on site productivity in coastal B.C.	Mike Curran: Ph.D. Thesis, UBC; support from MB	Coastal	Ongoing
Redroofs	To study compaction and growth impacts on skidder logged site	Robert Laird and Bob Green, MoFL	Coastal; Sechelt	Ongoing
Soil Compaction and and Seedling Performance	To analyse the relationship between soil compaction and seedling performance	G. Kannah, MoFL	Sechelt Area, Vancouver Forest Region	Ongoing
Gates Creek Stumping Project	Stumped to control *Phellinus weirii;* soil disturbance study	Dick Smith, CFS	TFL49-Vernon (Crown Forest Products)	Soil&vegtation studies commenced in 1981; ongoing
Phoenix Stumping Project	Stumped to control *Armillaria ostoyae;* soil disturbance study	Dick Smith, CFS	Grand Forks, Boundary Forest District	Soil&Vegetation studies commenced in 1981; ongoing
Marl Creek Stumping Project	Stumped to control *Armillaria ostoyae;* soil disturbance study regarding stumping and contour skidroads	Dick Smith, CFS	Golden	Soil&Vegetation commenced in 1984; ongoing
Shawnigan Lake Stumping Project	Stumped to control *Phellinus weirii;* soil disturbance study	Dick Smith, CFS	South of Shawnigan Lake: Duncan Forest District	Soil disturbance surveys undertaken in 1985/86
Effects of a Stump Pulling Operation on Surface Soil Densities	To determine if any significant change in soil bulk density was induced by three different stump pulling operations	Terry Rollerson, MB in cooperation with CFS	Cowichan Lake area	Reported in April
Effects of Prescribed Burning on Soil Properties and Productivity	To evaluate the impacts of fire on soil properties and and seedling performance	Tom Braumandl, MoFL Nelson; and Steve Thompson	ICHa, Nelson Forest Region	Ongoing

CURRENT AND PROPOSED RESEARCH ON SOIL DEGRADATION

Table 1c. SITE REHABILITATION

TITLE	OBJECTIVES	PRINCIPAL RESEARCHER	LOCATION	TIMING
Reforestation of Debris Slides	To compare hydroseeding alone to hydroseeding plus Sitka alder in row and grid patterns; to test 6 native shrubs for potential slide reforestation	Bill Beese, MB	Queen Charlotte Islands	Completion by 1989
Landslide Reforestation	To test the benefits of interplanting conifers with Sitka alder in rows; to test 4 native shrub, 4 conifers, 3 hybrid poplars & 3 hybrid willows for use on landslide reforestation; to test direct seeding of Sitka alder in hydroseeding mixes	Bill Beese, MB	Northeast of Ucluelet, Vancouver Island	Completion 1991
Revegetation Trials; cut/fill slope stabilization	Revegetation trials conducted in all 6 Forest Regions and in most significant biogeoclimatic zones; benchmark research test sites established; specifically looking at cut/fill slopes in regard to timing and seed mixes for stabilization	Steve Hamoky; Research Branch, MoFL Victoria	All Provinces	Some results published 1982 and 1987
Use of Erosion Control Netting to Reduce Soil Loss	To examine the use of erosion control netting for purposes of reduction of soil loss; quantification of surface soil loss	Steve Hamoky; Research Branch, MoFL Victoria	Coast	Results published in 1988

TITLE	OBJECTIVES	PRINCIPAL RESEARCHER	LOCATION	TIMING
Evaluation of the Ripping Effectiveness of a Winged Subsoiler for Soil Decompaction in the Prince George Forest Region	To determine the effectiveness of a winged subsoiler for soil decompaction	Angus McLeod, MoFL and Bill Carr	Prince George	To be completed by February 1988
Rehabilitation of Degraded Forest Soils in the Prince George Forest Region	To examine the efficacy of soil rehabilitation	Angus McLeod, MoFL and Bill Carr	Prince George	MoFL publication
Magnitude of Compaction on Various Manmade Structures in the Fort Nelson Forest District	To examine the degree and extent of soil compaction in the Fort Nelson Forest District	M. Osburg and S. Jenvy, MoFL	Fort Nelson Forest District	Completed as internal memo
Matthew Creek Wildfire Rehabilitation	To evaluate the effectiveness of low intensity aerial grass seeding for erosion control	Tom Braumandl Steve Thompson Gerry Still	Nelson Forest Region	Published 1988

CURRENT AND PROPOSED RESEARCH ON SOIL DEGRADATION

Table 1d. MONITORING SYSTEMS

TITLE	OBJECTIVES	PRINCIPAL RESEARCHER	LOCATION	TIMING
A procedure for quantifying the volume loss associated with degraded areas and transition zones in the Prince George Forest Region	To quantify the relationship between productivity loss and soil degradation	Angus McLeod, MoFL	Prince George	Presented at 10th Soil Science Workshop
Assessing the historical development of seedling performance on landing areas in the Prince George Forest Region	To compile existing information regarding seedling performance on landings	Angus McLeod, MoFL Bill Carr	Prince George	To be completed by Jan. 1988
Assessment of landing rehabilitation activities in the Prince George East Forest District	To compile and analyze existing knowledge regarding landing rehabilitation	Bill Carr	Prince George East Forest District	Completed
Soil disturbance measurements in Arrow and Kootenay Lake TSA	To determine variability of disturbance over a cut block to help devise best sampling methodology	Steve Thompson Gerry Still Tom Braumandl	Nelson Region	Ongoing
Quantification of soil disturbance associated with timber harvesting in the Golden TSA	To determine levels of soil disturbance commonly associated with summer and winter ground skidding operations	Steve Thompson Gerry Still	Golden	Published 1988

CURRENT AND PROPOSED RESEARCH ON SOIL DEGRADATION

TABLE 1e. TECHNOLOGY TRANSFER

TITLE	OBJECTIVES	PRINCIPAL RESEARCHER	LOCATION	TIMING
Training Programs Regarding Techniques of Erosion Control	To conduct training programs to instruct operational foresters in techniques of erosion control	Steve Hamby, Research Branch Victoria	All Province	Ongoing
Okanagan Resource Guidelines Committee	Development of guidelines for resource management	MoFL, DFO, MoEP, South Okanagan Forestry Assoc.	Kamloops Forest Region	Ongoing
Steep Slope Logging Subcommittee	Report to TSA Committees regarding impacts of soil degradation on productivity	MoFL & Industry; contact David Meehan, Weyerhaeuser (Vavenby)	All Province; mainly interior	Ongoing
Soil Interpretations Working Group	To develop interpretations regarding erosion hazard, compaction hazard and sensitivity to timber harvesting practices	Bob Mitchell, Kamloops Forest District	All Province	Ongoing
Timber Harvesting Practices Interpretations Subgroup	To develop interpretations regarding harvesting methods and site rehabilitation	—	All Province	Ongoing

TITLE	OBJECTIVES	PRINCIPAL RESEARCHER	LOCATION	TIMING
Guidelines for landing debris disposal and rehabilitation	To prepare guidelines for effective debris disposal and rehabilitation of landings	Angus McLeod, MoFL	Prince George	Completed; being used in Region
Better harvesting practices for protecting forest soil	Communication of concepts for soil protection	Paul Diggle, Silviculture Branch MoFL	All Province	Published 1987
Ground Skidding Guidelines	Proposed guidelines for skidder logging to aid in reduction of soil degradation	Zsolt Bige, Ken Nelson, Dave Laerie, Einar Kvarv and Paul Diggle MoFL	All Province	Ongoing
Forest Site Degradation Committee	To provide recommendations and promote research and training programs related to degradation and rehabilitation	Angus McLeod MoFL Chairman	All Province	Ongoing
10th B.C. Soil Science Workshop Proceedings	Communication of research results	———	———	To be published 1988
Maintaining Productive Forest Soils	Short brochure to briefly state rationale of soil protection	Gerry Still Donna Macdonald	———	Published 1987

the issues, in part, because of insufficient information relating causes and effects, and consequently a fear of overreacting. Tables 1a to 1e show that there is little effort being directed at this knowledge exchange problem (which is essential for consensus to be achieved) other than by way of a variety of government/industry committees and subcommittees (e.g. Steep Slope Logging Subcommittee, Forest Site Degradation and Rehabilitation Committee, Interpretations Working Group, etc.). The current and proposed research previously outlined will provide some of this specific knowledge and thereby assist in reconciling some of the present misconceptions and misunderstandings. However, the problem of effective dissemination of research results (i.e. effective information exchange) still remains.

3.3 RESEARCH NEEDS

As previously mentioned in this report and more specifically in the Phase I report, soil is a basic resource whose health will affect our present and future ability to grow commercial tree species. A myriad of soil types exist in B.C., each with a unique set of characteristics which affect their capability to grow trees or their suitability to be managed. Numerous examples exist in the province where improper management has resulted in a serious reduction in the capability of the soils to produce sustained levels of goods and values. The converse is also true. There are many examples where soils have responded to specific management practices so that their full potential was achieved, often exceeding the potential under natural conditions.

While we in B.C. have been favoured in the past with an excess of timber supply relative to demand, it is a fact that increasing demands coupled with a shrinking forest land base compel us to manage in such a way as to maximize the long-term productivity of each hectare of land. The basic economic demands of private industry also require that economically efficient practices and techniques must be employed. Hence, the conundrum which constantly faces forest land managers: the most economic practice in the short-run can often cause the greatest soil degradation and therefore result in higher costs (lost productivity) in the long-run. There is a need for a balance between long-term productivity and short-term economic efficiency.

Proposed research topics have been developed through:

1. Discussions with foresters, silviculturalists and soil scientists in both the Federal and Provincial governments.
2. Discussions and interviews with researchers and foresters in the U.S. Pacific Northwest.

3. A review of current and proposed research activities in B.C. (see section 3.2).

In order to facilitate a better understanding of the proposed research topics, they have been segmented into six categories which are similar to the categories used to outline current and proposed research activities in the province. Tables 2a through 2f contain a listing of the proposed topics as follows:

1. Harvesting Technology - Table 2a
2. Site Preparation - Table 2b
3. Site Rehabilitation - Table 2c
4. Prediction, Assessment and Monitoring - Table 2d
5. Planning - Table 2e
6. Economics - Table 2f

Each of the specific research topics listed in Tables 2a through 2f need not be viewed as a single project. Rather, research proposals should incorporate several topics. For example, research examining the influence of soil compaction on productivity could incorporate the design of a system to identify sensitive soils as well as the most efficient means of surveying and monitoring soil conditions. Regardless of the nature and extent of the research undertaken it is essential that rigorous scientific design methods are employed so that data are both reproducible and acceptable to the scientific and non-scientific community. Anecdotal information from uncontrolled operational activities or trials can be useful, but can also be misleading, and cannot replace results from controlled, statistically rigorous research. Data and resultant conclusions that are incorrect or incomplete are often more of a detriment than an aid in problem resolution.

It is for these reasons that research undertaken must meet four criteria:

1. Research must be experimental; treatment must be imposed (e.g. different levels of compaction) and replicated.

2. Experiments must be designed in such a way that treatment effects can be separated by environmental characteristics; stratification by biogeoclimatic unit, and soil type will assist in this regard. In all cases, measurements of important environmental variables (e.g. nitrogen, water, light regimes) must be included.

3. Plots should be maintained for a minimum of twenty-five years and preferably longer (particulary in regard to productivity measurements).

4. Monitoring of research projects must commence prior to the initial treatments. Ignorance of historical factors on study plots has a high probability of leading to unexplainable results.

The majority of these proposed research topics are encompassed by seven major initiatives which should receive high priority.

Table 2a. Research Needs Regarding Soil Degradation Effects on Forest Productivity - Harvesting Technology

1. Investigation of the effects of roads and road-building on forest productivity.

   Such a study should provide some answers as to why trees sometimes grow better on rights-of-way (at least in the short-term) and if trees growing on undisturbed spots benefit from being adjacent to slower growing trees in disturbed areas. The issue of seepage interception should be thoroughly investigated by this study.

2. Investigations to elucidate what soil changes might be expected from specific harvesting machines now in common use as well as new types being introduced.

3. Investigate the manner by which fireguards are planned and constructed in order to determine if there are means of reducing their contribution to the percentage of degraded area in a cut-block. For example, are widths sometimes greater than needed?; should different equipment be used for construction in order to reduce compaction and erosion on some sites?

Table 2b. Research Needs Regarding Soil Degradation Effects on Forest Productivity - Site Preparation

1. The evaluation of forest management activities such as slashburning, scarification and herbicide use on site productivity.

   The study should provide the means of quantifying productivity gains or losses on the basis of soil characteristics in order to determine which sites are best suited to each alternative.

2. Investigation of the effects of intensive forest management (mechanization of thinning and fertilization; large scale biomass removal) on soil degradation.

Table 2c. Research Needs Regarding Soil Degradation Effects on Forest Productivity - Site Rehabilitation

1. The preparation of guidelines aimed at the selection of appropriate sites for soil rehabilitation; to enable the selection of sites where there is a sufficient chance to recover lost productivity.

2. To investigate the effectiveness of specific rehabilitation techniques, or combination of techniques, in relation to site conditions by measuring subsequent tree growth and productivity.

Table 2d. Research Needs Regarding Soil Degradation Effects on Forest Productivity - Prediction, Assessment and Monitoring

1. Long-term study (full rotation) to ascertain the effects of various kinds and degrees of soil disturbance on site productivity.

   The study goal being to establish baseline estimates of productivity changes related to tree species, soil type and climatic (biogeoclimatic) regime. This is perhaps best performed by way of plantation studies on areas which are deliberately treated to create various types and degrees of soil degradation/disturbance. The study should generate comparative data on survival, growth and yield on various types of disturbance in various geographic areas.

2. The development, testing and establishment of a relatively simple, quick and reliable method for estimating the extent of soil degradation/disturbance over an area.

3. Through the application of research results and operational experience, provide a simple, definitive consensus of what constitutes soil degradation.

4. The development, testing and establishment of a simple, quick and reliable system for monitoring soil degradation.

   Such a system would be useful for establishing guidelines as well as to monitor the extent of disturbance following harvesting and site preparation.

5. By way of selective sampling techniques, determine the amount and nature of cutblocks in the interior which meet the proposed guideline standards of acceptable disturbance.

6. To investigate the importance of productivity losses on limited site-specific areas within a stand to productivity of the stand as a whole. For example, what is the effect of compacted skidtrails covering 10% of the stand area on the productivity of the stand as a whole?

Table 2e. Research Needs Regarding Soil Degradation Effects on Forest Productivity - Planning

1. The continuation and enhancement of existing soil degradation/steep slope working groups and committees made up of industry and government.

   The objective being to foster a good working relationship between researchers and foresters in industry and government so as to negate any adversarial situations which may arise. For example, the use of the pre-logging conference (MoFL plus industry plus contractor plus other affected parties) works well and should be fostered.

2. Design extension programs, working mainly with MoFL District staff, to convey not only the impact of visible degradation (compacted soil, erosion, loss of organic matter, etc.)on site productivity, but also the impact of degradation which is not readily visible (e.g. loss of nutrients, interception of subsurface flow).

3. Design effective programs (workshops, reports, etc.) that provide the means of getting important information out to the users (e.g. MoFL Districts, Industry, Contractors).

4. To investigate the effectiveness and costs of utilizing pre-planned and designated skidtrails to reduce or avoid soil degradation.

5. To provide inventory data, by way of Biogeoclimatic subzones within Forest Regions and Districts, of potential soil degradation problems in order to provide a data base for AAC calculations.

   Such a study could use existing soil and biogeoclimatic mapping and forest inventory data to map the distribution of sensitive sites. This is viewed as an extension to the current system of determining "environmentally sensitive sites" in that it would key in on soil/ climate characteristics and be linked to a TSA analysis.

Table 2f. Research Needs Regarding Soil Degradation Effects on Soil Productivity - Economics
1. To undertake short and long-term economic analyses to quantify the effects of soil degradation on forest productivity in order to provide a mechanism for establishing realistic rates of harvest in the context of sustained yield forest management. Such a study is perhaps best suited to being incorporated in a TSA analysis. It will greatly aid in providing quantifiable data to base economic tradeoff decisions in the long and short-term. Further, the study can focus on a selected portion of the Province which will allow for more specific data to be gathered in comparison to a Provincial average. Such a fine-tuned data base will be of long-term value to planning efforts. 2. To investigate the present system of valuation/stumpage in light of the issue regarding who should pay (industry or government or both) for recovering lost productivity and the avoidance of future productivity losses resulting from soil degradation.

The individual research topics listed in Tables 2a to 2f are intended to serve as a basis for specifically addressing these major initiatives. The seven initiatives are:

1. The Branch level of the Forest Service, with the support of the ministry executive, should develop, test, implement and enforce a procedure on soil productivity protection.

2. Each Forest Region should develop and implement appropriate practices to rehabilitate soils whose productivity has been degraded.

3. Each Forest Region should develop specific soil monitoring plans and procedures to investigate and evaluate changes in soil productivity.

4. Each Forest Region (and District when and where required) should assess the potential for improving productivity by the use of soil-amendments and nitrogen fixing species.

5. Each Forest Region (and District when and where required) should develop techniques for assessing soil productivity potential and predicting where a reduction of productivity can be expected because of management practices and specific soil conditions.

6. Each Forest Region and the Branch Level of the Forest Service should design and implement effective programs (work-shops, reports, training sessions) that provide the means of getting important information out to user groups in a timely and understandable manner.

7. Each Branch of the Forest Service, and Forest Regions (and District when and where required) should identify and carry out specific research to evaluate the effects of management practices on specific soils with involvement from the universities and other research institutions.

These seven initiatives for resolution of soil degradation concerns are considered the most feasible alternatives for addressing the soil degradation issue. In large part, by accepting these approaches we will go a long way toward the realization of the goal to protect and improve soil productivity. However, it is recognized that Forest Regions do not have the authority or mandate to develop policy per se. Policy is usually developed at the Branch level of the Forest Service. Consequently, for the Forest Regions to undertake the seven initiatives mentioned, it is necessary to have the support at the Branch level and political level by virtue of legislation and resolve. Without the political, administrative and financial support, the Forest Regions and Districts cannot take effective action to address these issues.

4. LEGISLATION, REGULATIONS AND POLICIES

4.1 INTRODUCTION

In order to put the situation in B.C. in perspective, a brief synopsis is presented in this chapter on relevant legislation and policies regarding soil protection and conservation from other jurisdictions. This summary is not intended to be exhaustive. The reader is encouraged to review the relevant material from these other jurisdictions in order to gain a more detailed understanding.

It is the case not only in B.C., but also in other jurisdictions, that there is often an overlap among specific pieces of legislation or policies regarding soil protection and conservation. This is to be expected since soil is a fundamental resource for a variety of social and economic endeavours (e.g. forestry, agriculture, recreation, fish and wildlife, water quality, etc.). Consequently, it is necessary to realize that not all of the material discussed in this chapter deals specifically with soil degradation/forest productivity issues. However, only those pieces of legislation or policy that are, for the most part, relevant to the topic of this report will be outlined.

4.2 JURISDICTIONS OUTSIDE OF B.C.

United States - Federal

1. **Highly Erodible Lands Act. of 1983** (U.S. Senate)
   - : related mainly to agriculture
   - : identified lands that demand special attention regarding soil conservation
2. **Soil Conservation Act of 1984** (House of Representatives)
   - : replaced the 1934 act
   - : relates mainly to agricultural lands
   - : individual state forestry agencies assist in implementing conservation reserve practices
3. **Organic Administration Act of 1897**
   - : the main objective is to protect the public forest and National Forests from destruction by fire and depredations
4. **Multiple Use-Sustained Yield Act of 1960**
   - : authorizes the Secretary of Agriculture to develop and administer the renewable surface resources of the National Forests for multiple use and sustained yield
   - : one of the principle objectives is to achieve and maintain forest products output without impairment of the productivity of the land.

5. **National Environmental Policy Act of 1960**

: the central purpose of the Act is to encourage productive and enjoyable harmony between man and his environment and to prevent or eliminate damage to the environment.

6. **National Forest Management Act of 1976**

: the principal objective is to ensure the maximum benefits of multiple use - sustained yield management in accordance with land management plans

: in addition to the Multiple Use-Sustained Yield Act, it places increased emphasis on the concern for protection and improvement of the soil resource.

U.S. Pacific Northwest States

1. **Oregon Forest Practices Act of 1971**

: recognizes the necessity of protecting and maintaining the forest environment (including soils)

: rules are outlined in "Oregon Forest Practice Rules and Statute" as administered by the State Board of Forestry

2. **Washington Forest Practices Act of 1973**

: similar to Oregon

: administered by Washington Forest Practice Board

Outside North America

An excellent review of soil conservation legislation from around the world is available from the Food and Agriculture Organization of the United Nations (Christy 1971).

Canada - Federal and Provincial

1. **Government Organization Act**

: authorizes Ministry of the Environment to be responsible for all matters not administered by other federal agencies related to preservation and enhancement of soil quality

2. **Ontario Conservation Authorities Act**

: provides means for establishment of a Conservation Authority designed to conserve, restore, develop and manage natural resources other than petroleum and mineral resources

3. **Alberta Soil Conservation Act**

: objective is to make responsible the person who owns, occupies or controls lands for taking active measures to prevent soil deterioration

4.3 BRITISH COLUMBIA

1. **Environmental Management Act**

: addresses detrimental environmental impacts in regard to a change in the quality of air, land or water which

substantially reduces the usefulness of the environment or its capacity to support life

2. **Ministry of Environment Act**
: principal objective is to encourage and maintain an optimum quality environment by managing and protecting land, water, air and living resources
3. **Environment and Land Use Act**
: administered by the Environment and Land Use Committee of Cabinet whose duties are to minimize and prevent the waste of resources and despoliation of the environment
4. **Forest Act**
: empowers the chief forester to assess the land in the province for its potential to grow trees continuously and to determine an annual allowable cut that can be sustained on an area
5. **Ministry of Forests Act**
: the purpose is to manage, protect and conserve the forest and range resources of the Crown having regard to the immediate and long-term economic and social benefits they may confer on the Province
: the Act provides for a 5 year resource program documentation which contains alternatives for increasing the productivity of forest and range land and for otherwise improving forest and range resources

6. **Land Act**
: authorizes the Minister of Forests and Lands to designate the most desirable use of any area of Crown Land and withdraw such area from disposition for any purpose other than the use so designated

4.4 MINISTRY OF FORESTS AND LANDS-SILVICULTURE POLICY

The Ministry of Forests and Lands, Silviculture Manual contains a policy statement regarding the reduction of productivity losses from logging operations (section 009 Pages 11 to 16 dated May 24, 1984). The policy statement, which is applicable throughout the Ministry, is as follows:

- all logging operations and related road construction over which the Ministry has jurisdiction will be planned and carried out in such a manner and using such equipment as to ensure that site disturbance leading to permanent loss of productive area or to site degradation is kept to a minimum
- logging plans must be submitted for all such logging operations as required

- if a logging plan indicates an unacceptable loss of productive area, approval of the plan will be withheld pending a comprehensive review leading to its satisfactory revision
- other disturbance causing site degradation shall not exceed limits established by the Regional Manager for the protection of site productivity
- necessary erosion-prevention or rehabilitation measures will be taken by the licensee during road construction and logging and within one year of completion of logging operations all unacceptable site disturbance will be treated by the licensee in accordance with established guidelines and procedures
- non-compliance with an approved logging plan by any licensee that results in an unacceptable loss of productive area or site degradation will be subject to penalty.

Discussions with numerous individuals (Paul Diggle and Mike Wyeth - Silviculture Branch; Fred Brahniuk and Frank Renshaw - Timber Policy Branch; Stephen Homoky - Research Branch; and others) have indicated that while this policy does exist, the procedures for implementation, which define acceptable levels of site disturbance, have not been fully established. Numerous drafts of proposals to administer the site degradation policy have been circulated for comment and review since 1985. However, to date, none have been officially endorsed by the Ministry executive, nor accepted by the forest industry. These draft procedures are currently under review by committees with industrial and government representation.

4.5 LEGISLATIVE AND REGULATORY NEEDS FOR FOREST SOIL PROTECTION IN B.C.

There is no provincial legislation that is specifically concerned with the protection of the soil resource for the purpose of maintaining forest productivity. The most significant piece of legislation in this regard, the Ministry of Forests Act, does not specifically address soil productivity protection. However, it does address the protection, maintenance and rehabilitation of forest and range productivity.

As previously discussed, there is policy outlined in the Silviculture Manual which addresses the reduction of productivity losses from forest operations resulting from soil degradation. Also, there is a proposed methodology for measuring detrimental disturbance and calculating the effects on productivity from forest operations.

When comparing this situation with other jurisdictions, it is apparent that B.C. does not have a complete and specific legislative framework for effectively dealing with protection of the forest soil resource. For example, the U.S. Multiple Use - Sustained Yield Act and the National Forest Management Act and their respective policy and regulatory framework are considerably more specific and deal much more effectively with this issue. However, it is also true that B.C. legislation is no less stringent and comprehensive regarding forest soil protection than other provinces of Canada. This may tend to provide a degree of comfort, but it is paramount to understand that no where else in Canada is the value of forest resource as high as in B.C. Consequently, B.C. must be at the forefront of establishing realistic legislation and an effective policy framework and workable regulations.

It is suggested that the underlying problem in B.C. is founded in the inadequacy of the Ministry of Forests Act regarding specific requirements for forest soil protection. Without a firm foundation of legislation, all of the policies and regulations which are designed to implement the legislation will be weakened. However, perhaps an even more important issue is the political resolve to modify existing legislation or adopt new legislation. Political resolve is, to a large extent, fostered by public concern. Should the public, or society at-large, not be concerned then politicians may view the issue as insignificant. However, it is generally accepted that society has an interest in protecting the forest soil resource and can impose its will so as to restrict uses which cause adverse alteration in productivity or soil quality. This expression of society's vested interest in maintaining long-term forest soil productivity is of utmost importance as a first step in providing the political resolve to enact new or change existing legislation. Laws do not develop in a vacuum. They are precipitated by society's values.

Given the magnitude of the forest soil degradation issue in B.C. (see Phase I Report) the need for an effective legislative and policy framework cannot be taken lightly. Legislators in B.C. must ensure that legislation directly addresses soil productivity protection.

The Forest Act and the Ministry of Forests Act are both appropriate vehicles with which to enact effective legislation. However, there are others, as indicated in Section 4.3. Degradation of forest soils is not just a forest management issue, it is also an environmental issue. Because of the potential duress that MoFL personnel may feel with respect to enforcing some regulations, it seems doubly appropriate to

support the issue in other Acts, particularly the environmental ones.

Legislation requiring the evaluation of productivity losses is required, but legislation is also needed that demands minimal soil degradation in the first place. The legislation must require that soil degradation standards be set, and that productivity changes (productivity losses and gains) be accounted for.

One possible mechanism is to require an evaluation of productivity changes due to soil disturbance/degradation as a component of the 5 year resource program documentation, as required in the Ministry of Forests Act.

Legislation alone will not ensure protection of soil productivity. Legislation must be accompanied by the political will to establish and enforce effective regulations. Policies must be developed and regulatory mechanisms put in place that provide the means of dealing with the issue of productivity reduction. Policies must be developed at the Branch Level for this purpose and the Forest Regions and Districts must be given the mandate, the tools and the budget, to enforce policies, and regulate activities. More responsibility for the regulation and enforcement of these policies should be vested at the Forest District level in order to ensure effective implementation.

4.6 SUMMARY

It can be concluded that there is very little specific legislation in B.C. or Canada that deals with forest soil degradation. While there are several pieces of legislation, mainly related to natural resource ministries that indirectly address the soil resource, none of them provide a comprehensive or integrated approach to the subject.

While it is interesting to review the intricacies of the U.S. legislation, it should be noted that attempting to utilize these as a model for B.C. is fraught with danger due to the significant differences in government and administrative frameworks.

The most significant piece of legislation regarding soil degradation/forest productivity relationships in B.C. is the Ministry of Forests Act and the Ministry Policies established under the Act. Given that a policy has been in place since 1984 and that the Ministry is apparently proceeding with the establishment of a set of standards and procedures to administer the policy, it can be concluded that B.C. will, in the near future, have the regulatory mechanisms to deal in part with the issue of soil degradation. Implementation of the policy at the Forest Region and District levels will

ultimately determine the effectiveness of the policy.

In this regard, it is necessary to understand that research has a significant role to play in the determination of standards and procedures as well as the implementation of policy. Section 3.3 of this report outlines a number of research topics which need to be addressed. This point is emphasized because if research results are not available for the preparation of realistic regulations then there is a danger of tipping the delicate balance between costs and benefits.

Legislators in B.C. need to address the adequacy of existing legislation to deal with the loss of productivity resulting from soil degradation. The Ministry of Forests Act should be amended or changed so that it specifically recognizes the requirement to protect and enhance the forest soil resource. Policies must be developed and the regulatory/enforcement instruments must be provided to the Forest Regions and, more importantly, the Forest Districts in order to motivate industry and government to manage the soil resource responsibly.

5. PERSONNEL REQUIREMENTS

Personnel requirements for effectively dealing with forest soil degradation issues in B.C. are best presented in terms of the various components of the problem. A comprehensive work program must address the following:

1. Development and implementation of policies, regulations, procedures and standards.
2. Training, education, and extension for operational personnel, and for improving awareness of managers and the public.
3. Research needs.
4. Planning, both operational, and for TSA analyses.
5. Monitoring of operational activities.
6. Assessments designed to effectively quantify historical and ongoing forest soil disturbance and degradation.
7. Rehabilitation of degraded forest soils.

Table 3 summarizes proposed staffing levels required to effectively undertake a comprehensive program at two different levels- a "Minimum" level, and a more concerted "Recommended" level. It should be emphasized that both programs must address every component of the soil degradation issue outlined above, in order to be effective. The minimum program, as the name implies, deals only minimally with many components. The recommended program is a more complete program that will effectively deal with historical and ongoing soil degradation issues. Both the minimum and the recommended programs will be discussed in more detail later in this section.

5.1 CURRENT MoFL STAFFING LEVELS AND WORKLOAD

Acquiring reliable information regarding current staffing levels and workloads within the MoFL was difficult for a number of reasons:

1. There is considerable variability among regions and districts in staffing complements, and in staff allocation to different forest management activities.
2. The MoFL is currently undergoing reorganization, and the final staffing hierarchy at regional and district levels is not known. Notwithstanding this, district offices, depending upon their size, may not be required to conform exactly to the final hierarchy.
3. Records for each forest region and district regarding staffing complements were not made readily available to us by the MoFL for the purposes of this report.

The information we could acquire (Jefferson 1988) suggests that staffing levels average around 40 Full Time Equivalents (FTE's) per district. However, there is considerable variability in district staffing levels across the province, depending on the size of the district and the specific workload at a given time. Of those 40 FTE's, approximately 20–25 FTE's (or about 50% to 60%) in each district are field–oriented personnel, while the remainder are administrative, supervisory, and technical support staff. The forest management and monitoring responsibilities of those 20– 25 FTE's include:

- timber
- planning
- engineering
- scaling
- silviculture
- recreation
- range
- wildlife
- protection

Of the above 20–25 FTE's, timber, engineering, silviculture, planning and, to a limited extent protection personnel all deal with soil degradation–related issues to some extent in the normal course of their duties.

In addition to the above responsibilities, the MoFL is charged with managing and administering the small business program (in effect making the MoFL the largest "licensee" in the province). The small business program in each district demands sufficient time of district professional and technical staff to adequately plan and implement engineering, timber harvesting, and silvicultural activities, and administer contracts in regard to the same. This program requires that district staff either undertake, or administer contracts to undertake, the full spectrum of forest management activities, including: inventory, planning, layout, construction, harvesting, monitoring, site preparation, planting, and miscellaneous silvicultural surveys.

There are 46 forest districts in B.C. Information from the silvicultural site history record system indicates that there have been an average of 131 openings initiated per district in B.C. over the last 4 years (MoFL 1988). It is important to note that variability for this statistic is very high – the minimum number of openings initiated in one district was 2 in one year, and the maximum was 668 for another. There are inherent problems in dealing with average figures that represent statistics with high variability. Nevertheless, the above information indicates that an average of between 20 and 25 field–oriented people, are responsible in each district for an average of 131 openings initiated each year. Only some of those 20 to 25 people (primarily planning, timber and silviculture staff) are likely to

have ongoing responsibilities pertaining to forest soil degradation. Other staff, such as protection, recreation and range, spend most of their time dealing with matters more specific to their disciplines.

These facts suggest that significantly fewer than 20 to 25 field- oriented staff are available in a district to deal with an average of 131 openings initiated every year. Currently, the normal duties of those people do not explicitly include the regulation of soil degradation, although it is clear that there is serious concern for the same in some districts where some regulatory efforts are being made.

Because of the variability of the above data, and some of the uncertainties that exist with respect to specific district staffing levels and field responsibilities, it is impossible to state categorically that staffing levels are inadequate to deal with soil degradation problems in every district. However, it seems likely that there is already too much work for too few staff in many districts. In districts where 668 openings might be initiated in a year instead of the average 131, staffing complements might need to be five times the average, just to adequately deal with "normal" responsibilities. The additional responsibility of monitoring and regulating soil disturbance will require staffing complements, if an adequate job is to be done. Until adequate district staffing levels are instituted and responsibilities assigned, and until such time as there are appropriate official regulations, procedures and standards in place, district staff are likely to continue to deal with soil degradation issues tentatively, if at all.

Regional staff specialists tend to facilitate operations on an extension basis in the districts. Their field responsibilities are not opening-related in an ongoing sense, so while they can assist the district staff in their day-to-day work, they do not do so on a regular basis. In addition, some regional specialists have training and research responsibilities. Other regional staff tend to be purely administrative or technical support personnel.

Branch positions are even further removed from the field. Branch level personnel tend not to deal with operations except at a very general level, and cannot be construed as complementing district operational activities, except in a peripheral way. The responsibilities attached to these positions are more related to policy development and provincial program coordination.

It is noteworthy that the MoFL has within the last year or two completed a "workload analysis" which potentially quantifies staff time spent on major responsibilities, by

district, region and branch. Although this analysis would be useful for assessing staffing level adequacy with respect to forest soil degradation, it was not made available for our use.

5.2 REQUIRED STAFFING LEVELS

This section proposes two levels of staffing and a comprehensive program that could be undertaken to effectively deal with soil degradation issues resulting from forest management operations. Table 3 summarizes both the program and the two staffing levels. Appendix I presents details of the analysis undertaken to arrive at the staffing level estimates.

5.2.1 A Soil Degradation Program

Policy, Regulations, Procedures and Standards

Even though the silviculture site degradation policy is currently in place, no effective procedures for implementing it have been officially established. Numerous drafts of such procedures have been circulated, but none officially endorsed by the Forest Service Executive. It is imperative that effective procedures for implementation of the policy be produced immediately if ongoing soil degradation from forest management operations is to be minimized. This will require an effort primarily at the branch level on the parts of the Timber, Silviculture, Engineering, and Research Branches as outlined in Table 3, but some effort on the part of regional staff will be required in order to formulate provincially applicable standards and guidelines, and in order to regionalize the same if appropriate.

Training, Education and Extension

Training and education are required primarily at two levels (see Chapter 6 for a more detailed discussion). The most important training must take place at the operational level in the MoFL Districts and with industry personnel. This level of training should emphasize practical applications and techniques, including: basic soil management principles, efficient engineering planning and layout, techniques for measuring soil disturbance, evaluating site sensitivity, estimating productivity effects, evaluating rehabilitation chance and prescribing rehabilitation activities.

An additional educational effort is required to create or improve awareness of forest soil degradation issues for medium and upper level forest managers and the public. The objective of this level of education would be to create an environment which encourages soil conservation efforts at the operational level.

Table 3: Personnel requirements for implementation of two levels of a provincial soil degradation program.

AGENCY	FUNCTION	ACTIVITIES	PERSONNEL REQUIREMENTS* (full-time equivalents) MINIMUM	RECOMMENDED
Branch Offices	Research Branch: -planning and coordination -training and extension Timber, Silviculture, and Engineering Branches: -policy/regulations development -determine procedures/standards	-develop appropriate regulations, procedures and standards -determine provincial research priorities -disseminate research results -support for training of district and regional staff -create/improve public awareness	1 (1)	1 (1)
Regional Offices	-research (research staff)	-productivity effects -soil disturbance measurement -rehabilitation -minimizing soil disturbance	3	6
	-extension (silviculture, timber, engineering and research staff)	-train district staff: -measuring soil disturbance -evaluating site sensitivity -basic soil management principles -estimating productivity effects -engineering planning/layout -create/improve public awareness	(1)	1
	-coordination (silviculture, timber, and research staff)	-set/determine regional standards, regulations and procedures -ensure consistency of application	(2)	0.5 (2)
	-operational consultation (research, engineering, timber and silviculture staff)	-disturbance measurement -harvesting systems planning/layout -management prescriptions -site sensitivity assessment -rehabilition chance and techniques	0.25	0.5
Forest District Offices	-planning (planning and timber staff)	-TSA analysis - AAC effects -operational planning - cutblock layout/approval	3	5
	-monitoring (timber and silviculture staff)	-licensee/contractor harvesting, site prep. and rehab. activities	4	8
	-assessment (timber and silviculture staff)	-measure/estimate harvesting/site prep. disturbance by cutblock -estimate productivity effects -document: refer to district planner for TSA analysis re: AAC effects	(23.5)	4 (23.5)
	-rehabilitation (silviculture and timber staff)	-evaluate rehab. chance/feasibility -prescribe rehabilitation activities -estimate productivity effects and refer to district planner	1	2
		TOTALS	12.25(27.5)	28(26.5)

* Personnel requirements in brackets are "one-time only", other personnel requirements are annual FTE's.

Research

A comprehensive research effort is required, as outlined in Section 3.3 of this report. Such a research program would help to realistically evaluate productivity effects for inclusion in TSA analyses, and develop techniques for minimizing soil degradation and rehabilitating degraded forest soils. This research should be carried out at both regional and branch (i.e. provincial) levels, because there are some issues that must be resolved regionally (e.g. productivity effects) and others that require a comprehensive provincial program (e.g. developing planning and harvesting systems to minimize soil degradation).

Planning

The district planning effort must incorporate productivity effects into TSA analyses if such analyses are to be realistic. In this regard, an effort at quantifying historical soil degradation is required to help determine if current AAC's require adjustment, and to provide a realistic productivity adjustment factor for inclusion in future analyses if no ongoing effort at quantifying soil degradation is to take place. An effort at quantifying soil degradation on an ongoing basis is recommended.

At an operational level, both in the small business program and in licensee operations, an additional effort in field planning and layout is required in order to minimize the occurrence of soil degradation.

Monitoring

Despite the MoFL's conviction to significantly reduce supervision and monitoring activities by MoFL district staff in the future (with more emphasis on intermittent auditing), we consider it mandatory that licensee and contractor activities be monitored more rigorously and intensively than has occurred in the past. Monitoring must include all relevant aspects of timber harvesting, silvicultural treatments and rehabilitation. It must occur in order to proactively regulate soil disturbance levels, and to facilitate extension at the operational level.

Assessment

As stated above, an effort at quantifying historical soil degradation is required to help determine if current AAC's require adjustment, and to provide a realistic productivity adjustment factor for inclusion in future analyses if no ongoing effort at quantifying soil degradation is to take place. It is recommended that a minimum of 30 blocks per TSA be chosen for assessment (using the

design developed by Thompson and Still, in progress, or an equivalent design). The cut-blocks to be assessed should be chosen to adequately represent the district variation in terms of harvesting methods and seasons of operation, silvicultural treatments, operators, soil types and biogeoclimatic units. Clearly, the more blocks assessed, the more reliable will be the estimate of historical levels of soil disturbance and degradation. Future estimates of soil disturbance levels could be derived from approved harvesting plans submitted to the district staff by licensees, providing that such a system was put in place.

It is also recommended that an ongoing program of assessment be undertaken to accommodate blocks in each district that appear to be excessively disturbed, and require substantiation of the fact for administrative purposes.

Rehabilitation

Some effort at rehabilitation of severely disturbed areas is required for two reasons:

1. To recover some productivity on some of our most productive sites.
2. To act as a disincentive to licensees, assuming the responsibility for rehabilitation can be ascribed to the licensee.

Since little is known about effective rehabilitation and the amount of productivity likely to be recovered from a rehabilitation effort, it is inappropriate to recommend an expensive operational rehabilitation program. It is more appropriate to dedicate the limited available funds to the prevention of forest soil degradation, and to soil degradation research (aimed in part at developing effective rehabilitation techniques).

5.2.2 Minimum and Recommended Program Staffing Levels

Table 3 summarizes the above program in terms of Branch, Regional, and Forest District responsibilities, and outlines proposed staffing requirements to adequately address relevant components of the program. The proposed staffing requirements are irrespective of any current activities that are being undertaken by district, regional, or branch staff in the normal course of their duties. Therefore, what is proposed must be compared to what is currently ongoing, in order to determine what additional resources are required. Such a comparison could not reliably be made for the purposes of this report because of the inadequacy of the available information. It seems safe to conclude, however, that because no official procedures exist for implementing the existing silviculture site degradation policy and because current district workloads are

so heavy in relation to staffing levels, less soil degradation work is being done than is necessary.

The difference between the "Minimum Program" and the "Recommended Program" in Table 3 lies mainly at the operational level in the districts and in the area of research. There clearly needs to be a soil degradation program in the districts where soil disturbance actually occurs, and where it can be most effectively monitored and regulated. There also needs to be a rational and comprehensive research program to address the many critical unknowns.

The specifics of the "personnel requirements" analysis outlined in Table 3 are presented in Appendix I. It is particularly important to understand that, at the regional and district levels, FTE requirements for a given component of the program are apportioned more or less equally among the various regions and districts in B.C. Also, additional personnel requirements for many components of the program were determined on the basis of one or two additional work weeks for each of the 46 forest districts in B.C., and those district figures were summed to acquire a single FTE estimate for the province for each such activity. For example, district level monitoring requirements with respect to forest soil degradation for the minimum program were calculated based on monitoring activities on 20 blocks in each of the 46 districts, for 1 day per block. This works out to four work weeks per district per year, for a provincial total of 92 work weeks per year, or approximately 4 FTE's. Other similar calculations are outlined in Appendix I.

The "Soil Degradation Program" outlined in Table 3 proposes the following:

1. At the Branch level, effort is required to develop regulations, procedures and standards for implementation of the existing site degradation policy. It is estimated that roughly 1 FTE, apportioned between the Timber, Silviculture, Engineering and Research Branches is required to satisfactorily address this component of the program. This need only be a "one-time" FTE because once the above have been developed, a concerted effort in the future will not be necessary.

2. Effort is also required at the Branch level to determine provincial research priorities and coordinate a provincial research effort, disseminate relevant research results, liaise with other research agencies, create or improve public awareness, and support extension of relevant information to branch, regional and district staff. It is estimated that 1 permanent FTE in Research

Branch would adequately address these components of the program.

3. At the regional level, an increased research effort is required in order to adequately address the full spectrum of relevant issues. At the very least (i.e. the minimum program), immediate answers are needed with respect to efficient and reliable soil disturbance measurement in the field, and quantifying related productivity effects. This information would facilitate a reliable quantification of productivity changes from forest management operations on a TSA basis, and the subsequent setting of appropriate AAC's. The recommended program would permit the initiation of a more comprehensive research program, designed to address a broader spectrum of issues (e.g. appropriate harvesting systems, effective rehabilitation, etc.).

4. Also at the regional level, an intensive training and extension effort is required (discussed in more detail in Chapter 6). The minimum program allows for a one-time training effort across the province. The recommended program acknowledges the need for ongoing training and extension, in recognition of staff turnovers and the availability of new research information.

5. A regional effort is required to develop region-specific standards, guidelines, etc., and to coordinate the application of approved policies and procedures so as to ensure consistency of application within and between regions. Two one-time FTE's are proposed for development and testing of regional procedures, etc.; an additional 0.5 FTE is proposed for ongoing correlation and coordination in the recommended program.

6. Operational consultation pertaining to soil degradation issues, by regional specialists, will be required on an ongoing basis. The recommended program simply allows for more such work than the minimum program.

7. At the district level, an additional planning effort is required for TSA analysis purposes, and operationally in order to help minimize the occurrence of soil degradation. The difference between the minimum and the recommended programs primarily reflects a greater effort in the field planning and layout phase, directed at minimizing the occurrence of soil degradation (see Appendix I).

8. As stated above, monitoring of licensee and contractor activities must occur if appropriate forest soil management is ever to become a widespread reality. The minimum program proposes monitoring activities on 20 of the average 131 blocks initiated annually in each district. The proposed monitoring on each block is

estimated as requiring 1 day of a field person's time. The recommended program doubles the number of cutblocks monitored. It is important to note that these estimates pertain to monitoring harvesting, site preparation, and rehabilitation phases of forest management operations, not just harvesting activities. Obviously, monitoring activities on one block, for one day would not allow the full spectrum of forest management activities to be viewed on any one block. It is not clear that monitoring so few a number of blocks, for one day each, should be construed as an adequate monitoring program.

9. The proposed assessment program at the district level is comprised of measuring soil disturbance on 30 blocks in each district, chosen randomly, utilizing the methodology of Thompson and Still (in progress). The objective for this program is to acquire an estimate of average soil disturbance on a TSA basis for TSA analysis purposes. This is an essential activity and, alone, constitutes the minimum program for this component of the forest soil degradation program. The recommended program provides for a level of ongoing assessment for administrative purposes, as previously outlined.

10. Estimating the amount of rehabilitation effort required for both the minimum and the recommended programs is difficult, because so little information is available regarding the effectiveness of such rehabilitation efforts. Also, even though there are some regional directives dictating the rehabilitation of landings (for example), they are not always enforced, so it cannot be categorically assumed that all landings will be rehabilitated. Nonetheless, it seems appropriate to allow for some rehabilitation to occur, for reasons discussed above. The recommended program allows for twice the effort of the minimum program.

As previously stated, neither level of the above program takes the current efforts of MoFL, Industry, Universities or other agencies into account. For example, pre-harvesting inspections already occur; licensee/contractor activities are monitored to some extent, etc. However, it is clear from available information about current staffing levels, workloads, and responsibilities, that many critical components of a reasonable, comprehensive program are not being adequately attended to by the MoFL. For this reason implementation of a program similar to one of the above proposals is mandatory if forest soil degradation issues are to be satisfactorily resolved in the foreseeable future. Either level of the above proposed program, if adequately funded, would serve to resolve a significant number of shortcomings in the current MoFL

program. The "Recommended Program" is favoured over the "Minimum Program" because it deals with issues more adequately in the long-run, and more comprehensively.

5.3 DISCUSSION

By comparing the estimated costs of soil degradation to the provincial economy, with the estimated costs of personnel required to implement a soil degradation program it is possible to consider the potential benefits of such a program. Phase I of this study has estimated that soil degradation resulting from forest management activities during the ten-year period of 1975- 1985/86 is currently costing the provincial economy approximately $80 million, due to reduced forest growth (not including off-site damages). The accumulation of degraded areas resulting from areas harvested or treated each year, are estimated to be increasing the annual costs to the provincial economy by approximately $10 million per year.

The estimated annual costs of the proposed annual personnel levels are approximately $550,000 for the minimum program and $1.2 million for the recommended program (assuming an annual cost, including benefits, of $25,000/FTE for assessment field crews, $40,000/FTE for other district staff and $55,000/FTE for region and branch staff). Assuming that other related program costs and expenses would be about 30% of the staffing costs, estimated total annual costs for the minimum program are approximately $715,000, and for the recommended program are $1.56 million. Using the same assumptions, the total cost for the "one-time-only" program would be approximately $1 million. The proposed expenditure for the recommended program is approximately 0.35% of the Ministry of Forests budget for 1985/86 (MoFL 1986).

When compared to the annual increase in productivity losses (approx. $10 million), the recommended program is cost-effective, if it only reduces the annual accumulation of soil degradation by 26%, without even considering reductions in off-site damages. Program costs and staffing requirements will decrease with time, as awareness of soil degradation increases and improved planning reduces the occurrence of soil degradation. Research results should also improve the effectiveness of silvicultural treatments, resulting in further growth increases on some sites.

By comparison, in the State of Oregon there are approximately 10 million hectares of commercial forest land (Bassett and Choate 1974). British Columbia possesses approximately 52 million hectares (Bickerstaff et al 1981). British Columbia has about 18% of the productive forest land in Canada and accounts for approximately 27% of Canada's

total mean annual increment of wood fibre. There are some 10 to 15 public agency researchers in Oregon who devote at least part of their time to problems related to soil degradation. There are also research and operational personnel in forest companies and state organizations at least partly dedicated to these issues. In British Columbia, there are 6 regional pedologists and 3 headquarters staff (Research Branch and Silviculture Branch) who have only minor responsibilities associated with soil degradation. Given that the State of Oregon constitutes approximately 26% of the area of productive forest land in B.C., and employs 10 to 15 research personnel, it follows that B.C. may need 50 to 75 such personnel to conduct research and operational programs at the same level of intensity as in Oregon. The programs described in Table 3 call for staffing levels equivalent to approximately 13 personnel for the minimum program and 29 personnel for the recommended program. They would therefore constitute staffing levels of only 25% to 40% of those currently employed in Oregon.

6. EDUCATION AND TRAINING REQUIREMENTS

6.1 OBJECTIVES AND TARGET GROUPS

The education and training component of an overall soil degradation program has two main objectives:

1. To increase awareness and understanding of soil degradation/conservation issues among middle and upper level forestry managers and the general public in order to foster an environment which encourages improved soil management.

2. To train operational forestry personnel in planning and specific field techniques which will reduce the occurrence of soil degradation.

Five principal target groups have been identified as potentially benefiting from education and training programs:

1. Licensee and contractor machine operators directly involved in harvesting and site preparation.

2. Operational personnel from MoFL districts and planning/layout personnel from industry.

3. Middle and upper management personnel from MoFL and industry.

4. Students from forest technical schools and forestry-related university disciplines.

5. General public and politicians.

These groups have been separated because their relationships to soil degradation issues are distinct and therefore require distinctive approaches in education and training. The Phase I report pointed out that the skill and understanding of machine operators can have a significant impact on the extent of soil degradation resulting from any particular treatment. Phase I also indicated that improved planning and layout is probably the most cost-effective means of reducing soil degradation. The present lack of defined procedures and regulations indicate that middle and upper level forest managers do not have an awareness of the significance of soil degradation problems. To avoid future soil degradation, there should be more emphasis in the training/education programs of students who will assume roles as future forest managers and field personnel. Greater awareness among the general public and politicians will facilitate funding and legislation/policy development for programs to resolve soil degradation issues.

6.2 PROPOSED EDUCATION AND TRAINING PROGRAM OUTLINES

The following section proposes general outlines for education and training programs for each target group identified above. The trainers indicated are primarily sources of relevant knowledge related to the topics to be covered. It may be more practical to develop and present the courses/workshops on a contract basis, and the actual trainers may vary from region to region or from topic to topic.

MACHINE OPERATORS

Objectives: to provide machine operators with an appreciation of the significance of soil degradation and specific techniques to reduce soil degradation resulting from road construction, harvesting and site preparation.

Methods: field oriented practical workshops and demonstrations.

Trainers: FERIC, MoFL Silviculture and Engineering, MoFL Pedologists, Industrial and Operational Foresters, Consultants.

Topics: introduction to the significance of soil degradation
- field demonstrations of machine effects on soil properties and resulting degradation
- specific field examples of productivity losses due to soil degradation
- field demonstrations of specific machine operation
- techniques to reduce soil degradation during road construction, harvesting and site preparation

MoFL DISTRICT AND INDUSTRY FIELD STAFF

Objectives: to provide MoFL District and Industry planning, timber, silviculture, and protection staff and industry field planning/layout and supervision staff with an appreciation of the significance of soil degradation; methods for recognizing sensitive soils, monitoring and assessing soil degradation; and specific techniques to reduce soil degradation resulting from forest practices.

Methods: a combination of written manuals, lectures, workshops and field oriented practical demonstrations.

Trainers: FERIC, MoFL Silviculture and Engineering, MoFL Pedologists, Industrial and Operational Foresters, Consultants.

Topics: introduction to the significance of soil degradation
- basic soil physical, chemical and biological properties

- productivity losses due to soil degradation and their implications to TSA planning and the AAC
- off-site effects of soil degradation
- field demonstrations of specific machine operation and planning techniques to reduce soil degradation during road construction, harvesting and site preparation
- recognition of soils sensitive to specific forms of degradation and methods of prescription formulation to minimize soil degradation
- field sampling techniques to monitor and assess soil disturbance and soil degradation
- legislation, policy, procedures and standards related to soil and site degradation
- rehabilitation techniques, costs and results; methods of assessing sites for rehabilitation needs

MoFL AND INDUSTRY MIDDLE AND UPPER MANAGEMENT PERSONNEL

Objectives: to provide forest managers with an appreciation of the significance of soil degradation and specific techniques to reduce soil degradation resulting from road construction, harvesting and site preparation. Methods: a combination of written manuals, lectures, and workshops.

Trainers: FERIC, MoFL Silviculture and Engineering, MoFL Pedologists, UBC and CFS researchers.

Topics: introduction to soil physical, chemical and biological properties

- forest management as a cause of soil degradation
- productivity losses due to soil degradation and their implications to TSA planning and the AAC
- significance of off-site damages
- cost/benefit analysis of prevention, rehabilitation and ignoring the problem of soil degradation
- field demonstrations of specific machine operation and planning techniques to reduce soil degradation during road construction, harvesting and site preparation
- rehabilitation techniques and their effectiveness
- legislation, policy, procedures and standards related to soil and site degradation

FORESTRY STUDENTS FROM TECHNICAL SCHOOLS AND UNIVERSITIES

Objectives: to provide technical school and university students in forestry-related fields with an appreciation of the significance of soil degradation, and management techniques to minimize soil degradation.

Methods: additions to standard forestry-related curriculums and provision of guest speakers and/or workshops.

Trainers: technical school and university lecturers; MoFL, CFS, FERIC researchers or private specialists as guest lecturers.

Topics: two main courses - forest soils and tree nutrition; management of forest soils
- introduction to soil physical, chemical and biological properties
- forest management as a cause of soil degradation
- productivity losses due to soil degradation and their implications to TSA planning and the AAC
- significance of off-site damages
- field demonstrations of specific machine operation and planning techniques to reduce soil degradation during road construction, harvesting and site preparation
- rehabilitation techniques and their effectiveness
- legislation, policy, procedures and standards related to soil and site degradation

GENERAL PUBLIC AND POLITICIANS

Objectives: to raise the awareness of the general public and politicians of the importance of soil conservation and to convey what is being done to resolve soil degradation problems.

Methods: public information campaign using media advertising, pamphlets, public speakers (including at schools), demonstration sites.
Responsibility: MoFL Information, CFS, FERIC, Associations of Professional Foresters and Agrologists, B.C. Forestry Association.

Topics: the significance of soil degradation to forest productivity and off-site damages
- causes of soil degradation
- methods and programs for prevention and rehabilitation of soil degradation

6.3 DISCUSSION

At present and in the recent past, there have been limited and fragmented attempts at training and extension around the topic of soil degradation. These have primarily concentrated on erosion-related degradation and rehabilitation. There have also recently been some publications aimed at improving harvesting practices (MoFL 1987a and 1987b). The limited success of these fragmented approaches seem to point out the need for improved coordination and a more focused approach (as described above). People preparing training courses and/or extension materials need to be in direct contact with the researchers most knowledgeable in the field of soil degradation, as well as the

machine operators and field personnel (government and industry) ultimately responsible for the implementation of the training materials. The development of these training programs would be enhanced by the involvement of foresters and research scientists from outside of B.C. For example, individuals such as Dr. H. Froehlich (Oregon State University) and Mr. Steve Howes (USFS, Portland) would provide a wealth of experience and knowledge to such sessions.

Due to the fact that much has been learned in recent years regarding the effect of tree harvesting and silvicultural practices on soil productivity, individuals currently involved in research and decision-making could also benefit from additional training. This is also true because many of these individuals completed their formal training prior to the offering of courses on soil physical, chemical and biological processes. By way of short courses or workshops offered by the universities or the MoFL, it is believed that the necessary upgrading could be achieved. These training programs should be offered on a cooperative basis among the Silviculture, Research, Timber, Protection and Engineering Branches, and be made available not only to the forester or technician but also to the forest land manager. The involvement of the universities and research organizations such as the Forest Engineering Research Institute of Canada (FERIC) and Pacific Forestry Centre (CFS) will help strengthen the program. Such programs must not be made available solely to MoFL staff but include the forest industry as well.

It is believed that there currently exists in B.C. a substantial lack of awareness and understanding of the nature and extent of soil degradation in the province and the effective means of dealing with the problem. Through educational and training programs such as those previously outlined, it is expected that this situation will improve. As part of this, it is suggested that the development of field guides to predict site sensitivity to degradation and to recommend appropriate forest management and rehabilitation systems would be most useful. The short pamphlet produced for MoFL by Gerry Still and Donna Macdonald (1987) is a good start at beginning the process of creating awareness of the need to maintain productive forest soils.

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APPENDIX I
Detailed Calculations of Personnel Requirements and Program costs.

Recommended Program	FTE's		COSTS[1] ($1,000's)	
	one-time	annual	one-time	annual
Branch Offices				
-research coordination and extension	*	1	*	55
-timber, silviculture and engineering policies, regulations, procedures and standards	1	*	55	*
Regional Offices				
-research (1 FTE/region X 6 regions)	*	6	*	330
-training (annual training sessions & ongoing extension for 46 districts)	*	1	*	55
-develop regional standards and guidelines	2	*	110	*
-ensure consistency of application	*	0.5	*	28
-operational consultation (4 wks/region X 6 regions)	*	0.5	*	28
District Offices				
-TSA analysis and AAC effects (1 wk/district X 46 districts)	*	1	*	40
-operational planning/layout and approval (1 day/cutblock X 20 cutblocks X 46 districts)	*	4	*	160
-monitoring licensee/contractor activities (1 day/cutblock X 40 cutblocks X 46 districts)	*	8	*	320
-historical assessment of soil disturbance/degradation (30 blocks measured X 4 person-days/block X 46 districts)	23.5	*	588	*
-ongoing assessment of soil disturbance/degradation (5 blocks X 4 person-days/block X 46 districts)	*	4	*	100
-rehabilitation (2 weeks/district X 46 districts)	*	2	*	80
TOTALS	26.5	28	753	1196

[1] Assumes an annual cost, including benefits, of $55,000/FTE for Regional Branch staff, $40,000/FTE for District staff and $25,000/year for assessment field crews.

Minimum Program	FTE's		COSTS[1] ($1,000's)	
	one-time	annual	one-time	annual
Branch Offices				
-research coordination and extension	*	1	*	55
-timber, silviculture and engineering policies, regulations, procedures and standards	1	*	55	*
Regional Offices				
-research (0.5 FTE/region X 6 regions)	*	3	*	165
-training (one-time training sessions for 46 districts)	1	*	55	*
-develop regional standards and guidelines	2	*	110	*
-operational consultation (2 wks/region X 6 regions)	*	.25	*	14
District Offices				
-TSA analysis and AAC effects (1 wk/district X 46 districts)	*	1	*	40
-operational planning/layout and approval (1 day/cutblock X 10 cutblocks X 46 districts)	*	2	*	80
-monitoring licensee/contractor activities (1 day/cutblock X 20 cutblocks X 46 districts)	*	4	*	160
-historical assessment of soil disturbance /degradation (30 blocks measured X 4 person-days/block X 46 districts)	23.5	*	588	*
-rehabilitation (1 week/district X 46 districts)	*	1	*	40
TOTALS	27.5	12.25	808	554

[1] Assumes an annual cost, including benefits, of $55,000/FTE for Regional Branch staff, $40,000/FTE for District staff and $25,000/FTE for assessment field crews.